limb is observed, these bright lines indicating probably an outer shell of the photosphere of a gaseous nature.

iii. That a sun-spot is a region of greater absorption.

iv. That occasionally photospheric matter appears to be injected into the chromosphere.

May not these facts indicate that the absorption to which the reversal of the spectrum and the Fraunhofer lines are due takes place in the photosphere itself or extremely near to it, instead of in an extensive outer absorbing atmosphere? And is not this conclusion strengthened by the consideration that otherwise the newly discovered bright lines in the solar spectrum itself should be themselves reversed on Kirchhoff's theory? this, however, is not the case. We do not forget that the selective radiation of the chromosphere does not necessarily indicate the whole of its possible selective absorption; but our experiments lead us to believe that, were any considerable quantity of metallic vapours present, their bright spectra would not be entirely invisible in all strata of the chromosphere.

February 18, 1869.

Lieut.-General SABINE, President, in the Chair.

The Most Noble the Marquis of Salisbury and the Right Hon. Lord Houghton were admitted into the Society.

The following communications were read :—

I. " On the Structure of Rubies, Sapphires, Diamonds, and some other Minerals." By H. C. SORBY, F.R.S., and P. J. BUTLER. Received December 8, 1868.

[Plate VII.]

For many years Mr. Butler has had the opportunity of examining very many rubies, sapphires, and diamonds, and has taken advantage of it in forming a most interesting collection, cut and mounted as microscopical objects. He had very carefully studied the included fluid-cavities, and ascertained many curious facts. Mr. Sorby had for some time paid much attention to the microscopical structure of crystals, and published a paper* in which he showed that their microscopical characters often serve to throw much light on the origin of rocks. Mr. Butler therefore placed the whole of his collection in Mr. Sorby's hands for careful examination, and it was decided that a paper should be written by the two conjointly; and since Mr. Sorby had previously made many experiments in connexion with the expansion of liquids, as already described in a paper published in the Philosophical Magazine†, he took advantage of the opportunity to investi-

* Quarterly Journal of Geol. Soc., 1858, vol. xiv. p. 453.

† " On the Expansion of Water and Saline Solutions at High Temperatures," August 1859, vol. xviii. p. 81.

gate the law of the expansion of the very interesting fluid met with in the cavities of sapphire.

In describing the various facts, it will be well to consider them in relation to the following general principles :—

(1) The structure of the various minerals as mere microscopical objects.

(2) The physical characters of the fluid-cavities, as throwing light on the origin of the minerals.

(3) The influence of some included crystals on the structure of the surrounding mineral.

Sapphires.

By far the most interesting objects contained in sapphires are the fluid-cavities. Their occasional presence has been already noticed by Brewster[*], who met with one no less than about $\frac{1}{3}$ inch long, two-thirds full of a liquid which expanded so as to fill the whole cavity when heated to 82° F. (28° C.). He thought the liquid was less mobile than that described by him in topaz, and could not see a second liquid in the cavity. Though many thousand sapphires have been examined by the authors, no such large cavity has been found; but several have been met with about $\frac{1}{10}$ inch in diameter; the greater number are far less, and some are very minute; and they seem to contain only the liquid which expands so much when warmed. The size of the included bubble varies much, according to the temperature. At the ordinary heat of a room it is sometimes equal to one-half of the capacity of the cavity, whereas in other cases the cavity is quite full. This is especially the case with the very small cavities, and is to some extent due to the forced dilatation of the liquid. But if we only take into consideration the larger cavities, the temperature required to expand the fluid so as to fill them certainly varies from 20° to 32° C. (68° to 90° F.), and this not only in different crystals, but also, to a less extent, in the same specimen. As illustrations of the form of such cavities, we refer to Plate VII. figs. 1, 2, 3, and 4, the extent to which they are magnified being shown in each case. At the ordinary temperature the bubble in the cavity shown by fig. 1 is about one-half its diameter, but disappears entirely at 30° C. By carefully measuring the size of the cavity in various positions, and comparing it with the diameter of the bubble at 0° C., it appears that the liquid expands from 100 to 152 when heated from 0° to 30° C. Fig. 2 is a tubular cavity, and shows in a very excellent manner the boiling of the liquid when it cools after having been made to expand to fill the whole space. At the ordinary temperature the liquid occupies only about half the cavity; but when heated in a water-bath to 32° C., it fills it entirely. No bubble is formed until the temperature has fallen to 31°; and then innumerable small bubbles are suddenly formed, which rise to the upper part and unite; but instead of the liquid merely contracting by further cooling, it still continues to boil for some time, as represented in the drawing. Two other large cavities

[*] Söchting's Einschlüsse von Mineralien in krystallisirten Mineralien, p. 121, who refers to Edin. Journ. of Sc., vol. vi. p. 115.

contained in the same specimen also behave in the same manner, and become full and suddenly boil at almost absolutely the same temperature, as that figured. We need scarcely say that such cavities are extremely rare, and are very remarkable even when merely looked upon as microscopical objects, independently of their interest in connexion with physics. Fig. 3 is a tubular cavity of more irregular form, and is interesting on account of there being two plates of the sapphire projecting into the cavity so as to nearly divide it into three portions. At the ordinary temperature these partitions prevent the passage of the bubble from one part to the other; but by breathing on the object through a flexible tube, the slight increase of temperature expands the liquid so as to make the bubble small enough to pass into the next compartment; and a repetition of the process causes it to pass into that at the other end. Such plates projecting into the cavities are very common; and it is requisite to pay attention to this fact, since otherwise they might easily be mistaken for crystals of some other substance included in the cavity, which, if they ever occur, must be extremely rare, since no decided case has come under our notice.

In examining sections of sapphire cut in a plane more or less parallel to the principal axis of the crystal, the double refraction is so strong that two images of every object lying at any depth below the surface are seen, in such a manner as to make them very confused. This may be avoided by using polarized light without an analyzer, and arranging the plane of polarization so as to coincide with one of the axes of the crystal. High powers may then be used with perfect definition; and they show many small cavities, sometimes of most irregular forms, like fig. 4; and very often their sides are so inclined that they totally reflect transmitted light, and appear black and opake. In some specimens most of the cavities have lost their fluid.

Besides fluid-cavities, there are many small crystals of other minerals included in sapphires, but not so many as in rubies. The most striking are small plate-like crystals, often of triangular form, with one angle very acute. They are very thin, and give the colours of thin plates; so that when viewed by reflected light they look something like the scales from a butterfly. Seen edgewise, they appear as mere black lines, and are arranged parallel to the three principal planes of the sapphire, as shown by fig. 5. These small crystals and the minute fluid-cavities cause many sapphires to appear milky by reflected, and somewhat brown by transmitted light; and being arranged in zones related to the form of the crystal, they often show, as it were, lines of growth.

Rubies.

Though the ruby and the sapphire are of course essentially the same mineral, yet their structure is in many respects as characteristically different as their colour. The number of the fluid-cavities in rubies is far less, and the larger cavities are very rare, and only contain what appears to be water or a saline aqueous solution, as is shown by the amount of expansion when

the specimen is heated to the temperature of boiling water. Those containing a similar fluid to that included in sapphires do occasionally occur; and when they are minute, they are extremely interesting, since they show the spontaneous movement of the bubbles to greater perfection than any mineral that has come under our notice. This is perhaps to some extent due to the nature of the liquid, which is more mobile than the saline aqueous solutions contained in the cavities of the quartz of granite and syenite. It is manifestly a molecular movement analogous to that seen in all matter when very minute particles are suspended in a liquid, so as to allow freedom of motion; and the rapidity of the movement is certainly dependent on the size of the particles. It is not seen to advantage if the diameter of the bubbles is more than $\frac{1}{10000}$ of an inch; but when it is about $\frac{1}{50000}$ they move to and fro in the most surprising manner, with such rapidity that the eye can scarcely follow them.

The number of small crystals of other minerals included in rubies is often very great. There must be at least four different kinds; but it would be difficult to determine what minerals they all are. Some are very well characterized octahedrons, variously modified; and, as shown by fig. 5, their planes are very generally arranged parallel to planes of the ruby, and to the small plate-like crystals already mentioned in describing sapphire. These octahedrons have no influence on polarized light, and in general form and character correspond so closely with spinel that it seems very probable that they are that mineral. For some time we thought they were angular fluid-cavities filled with liquid; but when cut across in the sections they are clearly seen to be solid, though less hard than ruby. Many of the other included crystals are of such very rounded forms that, if it were not for their action on polarized light, they might easily be mistaken for cavities filled with some fluid. Most of these rounded crystals are colourless; but some are of more or less dark orange-red colour, and are certainly not the same mineral as the colourless or the octahedral crystals; and in all probability the thin and flat are a fourth kind. Occasionally alternating plates of ruby with their axes in different positions gave rise to a beautiful series of coloured stripes when examined with polarized light.

Spinel.

The ruby spinels from Ceylon sometimes contain fluid-cavities which differ in a striking manner from those of any other mineral that has come under our notice. One of these is shown in fig. 7. They are to a great extent filled with a yellow substance, indicated by the shading, which seems to be either a solid or a very viscous liquid. It incloses transparent, sometimes well-defined cubic crystals, which have no action on polarized light; transparent, prismatic, or plate-like crystals, which strongly depolarize it; and black opake crystals, either in larger pieces or mere grains. The rest of the cavity is in each case about one-third full of a colourless liquid, which seems to contract on the application of heat, because it passes entirely into

vapour, as occurred in some of the cavities in topaz described by Brewster. In this change it must expand about six hundred times less than when water passes into steam. Spinel also incloses crystals of several other minerals which we have not yet been able to identify.

Aquamarina.

The most striking peculiarity of this mineral is the occurrence of numbers of fluid-cavities containing two fluids and a vacuity, as shown by fig. 6.

Emerald.

Some of the specimens which we have examined are so full of fluid–cavities that they are only partially transparent. They differ entirely from those already described, and contain only one liquid, which does not sensibly expand when warmed. In all probability this is a strong saline aqueous solution, since the cavities also inclose cubic crystals, as shown by fig. 8, which dissolve on the application of heat, and recrystallize on cooling. On the whole, therefore, these cavities are very similar to those found in the quartz of some granites, and in some of the minerals found in blocks ejected from Vesuvius, as described in Mr. Sorby's paper on the microscopical structure of crystals, already referred to.

Diamond.

Few, if any, of the specimens of diamond that have come under our notice contain objects similar to those which, in the opinion of Göppert[*], are evidence of its having been derived from vegetable remains, but we have been able to study to great advantage some facts which do not appear to have presented themselves to either Göppert or Brewster. We have examined twenty-one objects similar to the two described by Brewster, in his paper in the Transactions of the Geological Society[†]; and this has enabled us to clear up some of the difficulties to which he alludes, and has led us to propose a different explanation. He thought that the black specks, which were surrounded by a black cross when examined with polarized light, were minute cavities; but at the same time he admitted that they were so small that it was not possible to say whether they contained a fluid or were empty. Judging from what we have seen of such small examples, we consider it impossible to say whether they are cavities or inclosed crystals; but fortunately we have met with several of such a size and character that it was quite easy to see that they were crystals. Fig. 9 is a most excellent example of this fact. The form is clearly that of a crystal, and it depolarizes light very powerfully. Its refractive power must be very much less than that of diamond; for the inclined planes totally reflect the transmitted light, and thus look quite black, as shown in the figure. It is this circumstance which causes many smaller inclosed crystals to appear like mere black specks.

[*] "Ueber Einschlüsse im Diamant," *Natuurkundige Verhandelingen,* Haarlem, 1864.   [†] 2nd series, vol. iii. p. 455.

Brewster has shown that the irregular depolarizing action of diamond is analogous to that of an irregularly hardened gum; and this much interferes with the perfection of the black crosses seen round the inclosed crystals, and sometimes even neutralizes this action.   Still, as a general rule, a black cross is seen; and, as described by Brewster, when examined by means of a plate of selenite which gives the blue of the first order, the tints of the sectors in the line of its principal axis are depressed in the same manner as when such a black cross is produced by the compression of glass—thus proving that the inclosed crystals have exerted a pressure on the surrounding diamond.   We, however, do not imagine that the crystals have increased in size, but that probably they have prevented the uniform contraction of the diamond, which, as already mentioned, must have been very irregular, even where no such impediment was present.   A few of the crystals inclosed in rubies give rise to similar black crosses, as shown by fig. 11 ; and we are informed by Professor Zirkel that his brother-in-law Professor Vogelsang has prepared a thin section of a specimen of partially devitrified glass, which also shows black crosses round the inclosed crystals.

Brewster suggested that this phenomenon in diamond was due to the elastic force of an inclosed gas or liquid, and compared it with what is seen in the case of some cavities in amber.   We, however, find that the optical character of the crosses seen round the undoubted cavities in amber is the very reverse of that in the case of diamond, and cannot be explained by the mere mechanical action of an included elastic substance, but is similar to the change to a crystalline state which has occurred over the whole external surface, and on both sides of cracks passing from it inwards.

The optical properties, however, are not the only evidence of contraction round crystals inclosed in diamond; for actual cracks are often seen to proceed from them.   These present the striped appearance shown in fig. 10, owing to more or less perfect total reflection from their waved surface. The same kind of phenomenon may be seen in sapphire, and still better in spinel, as shown by figs. 12 and 13.   Sometimes there is a system of radiating cracks nearly in one plane, terminating in a transverse crack which surrounds the whole, as in fig. 12 ; and in other cases there are various complicated wavy cracks in different planes, as in fig. 13.   There seems to be some connexion between this structure and the nature of the included minerals ; for round some kinds it is very common, but round others very rare or quite absent ; and it appears probable that it may be referred to unequal contraction in cooling from a high temperature ; and, if so, the results would necessarily depend on a variety of circumstances.   Now that attention has been directed to it, it will probably be found to be a very common peculiarity of certain classes of minerals, and serve to throw a good deal of light on their origin.

Crystals surrounded by radiating cracks on a much larger scale have

been observed by Mr. David Forbes[*], and may, we think, be explained in a similar manner.

The crystals formed in blowpipe beads kept hot for some time over the lamp, also furnish good illustrations of these facts.   Phosphate of zirconia is deposited in cubes from a borax bead to which much microcosmic salt has been added; and when examined with the microscope whilst cooling, cracks like those described in diamond and spinel are seen to be formed round many of the crystals, which are evidently due to the crystals contracting less than the surrounding material.   On the contrary, the long prisms of borate of baryta deposited from solution in borax are seen to separate from the borax on cooling, and to be filled with transverse cracks, like those in schorl inclosed in quartz, which is clearly owing to their contracting more than the borax.

Fluid-cavities in general.

Before discussing the nature of fluid-cavities in connexion with the origin of the various minerals, we think it best to describe the remarkable properties of the liquid included in the sapphire, and to point out what it seems to be.   Brewster, in his paper on the fluid-cavities in topaz[†], says that the more expansible liquid contained in them expands one-fourth its size, when heated from 50° to 80° F, or thirty-one and a quarter times as much as water; and, as already stated, he found that the fluid in sapphire expands about one-half when heated to 82° F.   Though this amount of expansion is very remarkable, yet, when the relative expansion at various temperatures is examined, it will be seen to be still more remarkable.   Very fortunately the tubular cavity in sapphire, shown by fig. 2, is most admirably fitted for experiment.   Mere inspection shows that its general diameter is very uniform; and that it is really so can be proved by causing the liquid to pass from one end to the other; for at $17\frac{1}{2}°$ C. the length of the column of liquid was $\frac{25}{400}$ of an inch, whether it was at the end A or B.   The total effective length of the cavity is $\frac{50}{400}$.

The specimen inclosing this cavity was fastened to a piece of glass, and this was fixed in a beaker containing water, supported so that the cavity was in the focus of the microscope under a low power.   The temperature was raised very slowly, and was maintained for some minutes at each particular degree at which it was thought desirable to measure the volume of the liquid; and this was usually repeated over and over again when the heat was both rising and falling, so as to obtain as accurate a result as possible.   In making the measurements with the micrometer, care was taken to allow for the tapering ends of the cavity and the curved surface of the liquid.   The results are given in degrees Centigrade.   Though the expansion below 30° was very great, compared with that of any other known substances except liquid carbonic acid and nitrous oxide, when the

* Ed. New Phil. Journ. July 1857.

† Trans. Roy. Soc. Edin. 1824, vol. x. p. 1.

temperature rose above 30° it was so very extraordinary that it was not until after having performed the experiment over and over again that Mr. Sorby felt confidence in the results.   This will not be thought surprising when we state that from 31° to 32° the apparent expansion of the liquid is no less than one-fourth of the bulk it occupies at 31°; the length of the column increasing for that single degree from $\frac{440}{400}$ to $\frac{507}{400}$ inch. This is about 780 times as great as the expansion of water would be, and even 69 times as much as that of air and permanent gases.   It was not possible to ascertain the amount of expansion above 32° C., because the cavity was quite filled at that temperature.   If the expansion increase at the same increased rate, the liquid would soon occupy several times as much space; but it seems very probable that before then it would pass into the state of gas.   At all events it appears as if this enormous rate of expansion indicated a close approach to a fresh physical condition.   The following Table gives the results of the experiments; and it has been found, by drawing them as a curve, that their general relations indicate that there cannot be any serious error; but at the same time, considering all the circumstances, they must only be looked upon as tolerably good approximations to the truth.

Temperature.	Volume.
0 C.	100
$17\frac{1}{2}$	109
20	113
25	122
28	130
29	139
30	150
31	174
32	217

The apparent expansion of the liquid is doubtless to some extent increased by the condensation of the gas, as the space occupied by it is diminished.   When in the highly expanded condition this liquid appears to be remarkably elastic.   Berthelot has shown, in his paper on forced dilatation *, that the force with which liquids adhere to the interior of a glass tube is sufficient to prevent their contraction to the normal volume, if they have been heated so as to expand and quite fill the tube, and then cooled to a temperature below that requisite to fill it.   This fact must always be borne in mind in studying fluid-cavities, and explains why the bubbles, as it were, hesitate to return, and then make their appearance with a sudden start.   Such a forced dilatation is very remarkable in the case described; for though it was requisite to raise the temperature to 32° C. to fill the cavity, no vacuity was formed until it fell to 31°; and therefore it seems as if the force of cohesion were sufficient to stretch it to considerably

* Annales de Chimie sér. 3. t. xxx. p. 232.

more than its normal bulk, even perhaps to the extent of one-fifth or one-fourth. Moreover, in the case shown in fig. 1., the liquid expanded so as to fill the cavity at about 30° C. ; and yet it can be heated up to 42° without bursting it, though, even if the expansion did not continue to increase, and were the same for each degree as from 31° to 32°, the normal volume would be about four times that of the cavity,—which in any case seems only to be explained by supposing that its elasticity is most remarkably great, more like that of a gas than of a liquid. There was no decided evidence of its passing into a gaseous state, as does occur when cavities contain a less amount of liquid.

Simmler * has shown that the physical properties of the liquid in topaz, as observed by Brewster, agree more nearly with those of liquid carbonic acid than with those of any other known substance. Dana, in his ' Mineralogy ' (5th edition, 1868, p. 761), calls it *Brewsterlinite*, and.says that its composition is unknown. The facts at Simmler's command were not in all respects satisfactory—since the amount of expansion given by Brewster was from 10° to 26°·7 C., whereas that of liquid carbonic acid observed by Thilorier was from 0° to 30°, and, as shown above, the expansion increases so much as the temperature rises that the average rate for 1° is very indefinite. The only reliable method is therefore to compare the expansion between equal degrees of temperature. According to Thilorier † liquid carbonic acid, when heated from 0° to 30°, expands from 100 to 145. One of the experiments described above showed that the liquid in sapphire expands from 100 to 152; and the other from 100 to 150, which is the most reliable. This agrees so closely with the expansion of liquid carbonic acid, that the difference might easily be due to a slight error in the thermometers. The expansion of ordinary liquids is not to be compared with it, nor is that of liquid sulphurous acid. Dr. Frankland has kindly ascertained this fact, with special reference to the case in question, and found that from 0° to 32° C. the expansion was only from 100 to 104·36 instead of to 217.

According to Andréeff ‡ the expansion of liquid nitrous oxide is not much inferior to that of liquid carbonic acid, being, from 15° to 20°, ·00872 for each degree, which differs decidedly from that of the liquid in sapphires. The occurrence of nitrous oxide in minerals is also so very much more improbable, that, on the whole, it seems as if we should be justified in concluding provisionally that it is liquid carbonic acid, which, like water, should therefore be classed amongst natural liquid mineral substances.

Brewster has shown § that when cavities in topaz contain less than one-third of their volume of the expansible liquid, it does not expand when heated, but passes entirely into the state of a compressed vapour. Un-

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* Pogg. Ann. vol. cv. p. 460.

† Gmelin's Handbook of Chemistry, Cavendish Society's Translation, vol. i. p. 225.

‡ Liebig's Ann. vol. cx. p. 1.

§ Trans Roy. Soc. Edin. vol. x. p. 25.

fortunately he does not state the temperature at which this occurs, nor does he seem to have tried to ascertain the exact limit of the volume, which must, however, lie between one-half and one-third. Cagniard-Latour* found that when ether and other liquids sealed up in small strong tubes, with a certain space left empty, were heated, they expanded very much, and suddenly passed into the state of vapour. The temperature, pressure, and volume at which this change took place varied very considerably. Ether expanded to nearly double its volume, and passed into vapour at about 200° C., with an elastic force of 37 or 38 atmospheres. Alcohol expanded to about three times its volume, and passed into vapour at about 260° C., with an elastic force of 119 atmospheres; whereas water appeared to expand to nearly four times its volume, and required a temperature near that at which zinc melts (328° C., Daniel). When in this highly expanded state, the liquids were very mobile, and seemed much more compressible than under other circumstances; for they did not burst the tube, if too much had been sealed up in it, until after their normal volume would have been decidedly greater than its capacity. No one could fail to see that these phenomena have much in common with what occurs at a lower temperature in the case of the liquid inclosed in sapphire, and that they are of great importance in connexion with the origin of fluid-cavities. Since they become full of liquid at a comparatively low temperature, it was not unreasonable to suppose that the minerals in which they occur must have been formed where the heat was scarcely above that of the atmosphere; but these facts seem to show that the occurrence of such fluid-cavities is quite reconcilable with a very high temperature; for it is obvious that if, at a great depth below the surface, heated, highly compressed *gaseous* carbonic acid were inclosed in growing crystals, it might condense on cooling so as to more or less completely fill the cavities with the *liquid* acid.

If the same principles could be applied in the case of water, we should be led to infer that it could not exist in a liquid state at a higher temperature than that of dull redness, corresponding closely with what Mr. Sorby deduced from the fluid-cavities in some volcanic rocks. In that case, according to Cagniard-Latour, the liquid when condensed would occupy only one-fourth part of the cavity, and it would scarcely be likely to contain any fixed salt in solution; whereas the fluid-cavities in the minerals of ejected blocks are often two-thirds full of what seems to have been a supersaturated solution of alkaline chlorides. The phenomena now under consideration should certainly be borne in mind in studying volcanic action; and it is possible that some cavities now containing water may have been formed by the inclosure of very highly compressed steam. In some cases the requisite pressure would be enormous, and other facts seem to show that it was more generally caught up in a liquid state.

The cavities in emerald are very interesting in connexion with this subject, and also furnish strong evidence against the opinion that the liquid was not

* Ann. de Chimie, 1822, t. xxi. pp. 127 & 178; t. xxii. p. 410.

present when the crystals were formed, but penetrated into the fluid-cavities at a subsequent period, and either filled vacant spaces, or removed and replaced the material of glass cavities, as suggested by Vogelsang *.   In the specimens which we have examined, each of the cavities contains what is no doubt an aqueous saline solution, and, as shown by fig. 8, one or more cubic crystals, probably chloride of potassium, which dissolve on the application of heat, and are deposited again on cooling.   These cavities are thus analogous to those met with in the quartz of some granite, and in the minerals of blocks ejected from Vesuvius; and it seems difficult, if not impossible, to explain them except by supposing that a strong saline solution was caught up by the mineral at the time of its formation.   In some cases the amount of such saline matter is so great in comparison to the liquid, that a high temperature would be requisite to make it all dissolve.   It also seems probable that, if water could penetrate into such crystals, it would soon be lost when they were kept dry.   This certainly occurs in some soluble salts, especially those containing combined water, and in some minerals of loose texture; but we have never seen evidence of it when fluid-cavities are completely inclosed in hard and dense substances like quartz or emerald.   Though in some instances the size of the bubbles does not bear a uniform relation to that of the cavities, yet in many cases the general proportion is very similar in each specimen; and the exceptions can easily be explained by supposing that occasionally small bubbles of gas were caught up along with the water, or that there was some variation in either temperature or pressure during the growth of the crystal; all of which conditions were discussed in Mr. Sorby's paper already referred to.

We have not had the opportunity of studying many examples of cavities which contain two fluids, probably water and liquid carbonic acid, and therefore forbear to say much about them.   According to Brewster † the temperature at which those in topaz become full corresponds very closely with what we have observed in the case of sapphire, so that the carbonic acid might have been inclosed either as a highly dilated liquid, or as a highly compressed gas; but since the other liquid has deposited crystals which dissolve on the application of heat ‡, it seems most probable that the water was caught up in a liquid state, sometimes perhaps holding a considerable amount of carbonic acid in solution as a gas.

On the whole, therefore, the various facts described in this paper seem to show that ruby, sapphire, spinel, and emerald were formed at a moderately high temperature, under so great a pressure that water might be present in a liquid state.   The whole structure of diamond is so peculiar that it can scarcely be looked upon as positive evidence of a high temperature, though not at all opposed to that supposition.   The absence of fluid-cavities containing water or a saline solution does not by any means prove that water

* Philosophie der Geologie und mikroskopische Gesteinsstudien, (Bonn, 1867) pp. 155, 196.

† Trans. Roy. Soc. Edin. vol. x. p. 1 *et seq.*

‡ See Brewster's paper, Phil. Mag. 1847, vol. xxxi. p. 497.

was entirely absent, because the fact of its·becoming inclosed in crystals depends so much on their nature.   At the same time the occurrence of fluid-cavities containing what seems to be merely liquid carbonic acid is scarcely reconcilable with the presence of more than a very little water in either a liquid or gaseous form.   We may here say that we do not agree with those authors who maintain that the curved or irregular form of the fluid-cavities is proof of the minerals having been in a soft state, since analogous facts are seen in the case of crystals deposited from solution.

EXPLANATION OF PLATE VII.

Figs 1. & 2. Fluid-cavities in sapphire ; magnified 20 linear.
Fig. 3. Fluid-cavity in sapphire, partially divided by plates of sapphire ; mag. 50.
Fig. 4. Branched fluid-cavity in sapphire ; mag. 50.
Fig. 5. Crystal of spinel ? inclosed in ruby ; mag. 50.
Fig. 6. Cavity in aquamarina, with two fluids ; mag. 150.
Fig. 7. Cavity in ruby spinel ; mag. 100.
Fig. 8. Fluid-cavity in emerald, with soluble crystals ; mag. 200.
Fig, 9. Crystal inclosed in diamond, surrounded by a black cross, as seen with polarized light ; mag. 100.
Fig. 10. Crystal inclosed in diamond, with a crack proceeding from it ; mag. 100.
Fig. 11. Crystal inclosed in ruby, surrounded by a black cross, seen by polarized light ; mag. 75.
Figs. 12 & 13. Crystals in ruby spinel, surrounded by various cracks ; mag. 50.

II. " Note on a Method of viewing the Solar Prominences without an Eclipse." By WILLIAM HUGGINS, F.R.S.   Received February 16, 1869.

Last Saturday, February 13, I succeeded in seeing a solar prominence so as to distinguish its form.   A spectroscope was used ; a narrow slit was inserted after the train of prisms before the object-glass of the little telescope.   This slit limited the light entering the telescope to that of the refrangibility of the part of the spectrum·immediately about the bright line coincident with C.

The slit of the spectroscope was then widened sufficiently to admit the form of the prominence to be seen.   The spectrum then became so impure that the prominence could not be distinguished.

A great part of the light of the refrangibilities removed far from that of C was then absorbed by a piece of deep ruby glass.   The prominence was then distinctly perceived, something of this form.

H.C Sorby del. W.H.Wesley lith.

W. West imp.